

CLAIMS

WE CLAIM:

1. A method comprising:
 - receiving in an Ingrained Sharing Directory Cache (ISDC) an incoming operation request including an associated incoming memory address;
 - locating pending operation in the ISDC pending queue;
 - completing a pending ISDC entry if the incoming operation is an ISDS data reply,
 - performing the operation, if there is an ISDC entry associated with the incoming memory address,
 - creating an ISDC entry if there is no ISDC entry associated with the incoming operation request; wherein creation includes,
 - requesting information associated with the incoming memory address,
 - wherein the information is requested from an Ingrained Sharing Directory Storage (ISDS),
 - evicting another ISDC entry if there is no free ISDC entry; wherein the eviction includes,
 - requesting the ISDS to store the information evicted from the other ISDC entry,
 - designating the evicted ISDC entry to the incoming request, and marking the evicted ISDC entry as pending; and
 - storing the incoming request into the ISDC pending queue.
2. The method of claim 1, wherein the ISDC entry associated with an incoming memory address indicates whether one or more cached copies of a memory line are in shared or dirty-exclusive state.
3. A method comprising:
 - receiving an Ingrained Sharing Directory Storage (ISDS) request;
 - selecting an entry in an ISDS, wherein the ISDS

includes

a plurality of coherence buffers, wherein each set of the coherence buffers maintains a dynamic full map of memory lines cached in a given set in system caches and evicted from an ISDC, wherein each of the coherence buffers maintains a plurality of cells, wherein each of the cells maintains a dynamic full map of shared lines cached in a given set of a given system cache and evicted from the ISDC, wherein each of the cells maintains a plurality of entries, each of the entries comprising a memory address of an associated memory line.

4. The method of claim 3, wherein the selecting includes, selecting one of the coherence buffers based on a SELECT_CB field of an incoming address of an ISDS request; and selecting one of the cells in the selected coherence buffer based on a SELECT_CELL field of an incoming address of an ISDS request, wherein value of the SELECT_CELL field is associated with one of plurality system caches; and using a MEMORY_TAG field of the incoming address or the VALID field or the eviction policy to select an ISDS entry.
5. The method of claim 4, wherein the ISDS request stores the MEMORY_TAG field and a state of the memory line into the one or more of ISDS entries.
6. The method of claim 3, wherein information about copies of a given memory line resides in only one of the coherence buffers.
7. An Ingrained Sharing Directory (ISD) controller apparatus for maintaining coherence of cache lines in a multi-cache system, wherein the ISD controller maintains a

dynamic full map directory of local memory lines cached in the system caches, and wherein the ISD controller comprises:

- an Ingrained Sharing Directory Cache (ISDC) to store information about memory lines recently cached in the system caches;
 - an Ingrained Sharing Directory Storage (ISDS) to store information about memory lines evicted from an ISDC; and
 - an ISDC pending queue to store pending ISDC operations.
- 8. The apparatus of claim 7 wherein the ISDC set and the ISDS set combined include all copies of memory lines cached at any point in time in the system caches.
- 9. The apparatus of claim 7, wherein the each of system caches is a set-associative cache.
- 10. An apparatus comprising:
 - an Ingrained Sharing Directory Cache (ISDC) to store state information about recent copies of local memory blocks, the ISDC to receive Ingrained Sharing Directory Storage (ISDS) requests and create ISDC entries from information presented by the ISDS; and
 - an ISDC pending queue to store pending ISDC operations.
- 11. The apparatus of claim 10, wherein the state information indicates whether the copy of local memory line is dirty exclusive or shared.
- 12. The apparatus of claim 10, wherein the ISDC requests are requests to fetch or modify the state information about the copy of the local memory line.
- 13. A system for maintaining coherence of cache lines in multi-cache system comprising:
 - a system interconnect; and
 - a first number of nodes connected via the system interconnect, wherein each of the nodes includes a local memory unit to store local data, wherein each local memory unit includes a plurality of memory lines, and wherein each node includes,

a second number of local set-associative system caches, and wherein each of the local caches comprise a third number of cache sets, and wherein each of the sets comprise a fourth number of cache lines; a local ISD controller, wherein the local ISD controller comprises, an Ingrained Sharing DirectoryCache (ISDC) to store state information about the recent copies of the local data; an Ingrained Sharing Directory Storage (ISDS) to store information evicted from the ISDC, wherein the ISDS includes a fifth number of coherence buffers, wherein each of the coherence buffers contains a sixth number of cells, wherein each of the cells contains a seventh number of ISDS entries and wherein an eighth number of ISDS entries is equal to the product of the first number of nodes, the second number of local set-associative system caches, the third number of cache sets, and the fourth number of cache lines; and an ISDC pending queue to store pending ISDC operations.

14. The system of claim 13, wherein the fifth number of coherence buffers is equal to the third number of cache sets.

15. The system of claim 13, wherein the sixth number of cells is equal to the product of the first number of nodes and the second number of local set-associative system caches.

16. The system of claim 13, wherein the seventh number of ISDS entries is equal to the fourth number of cache lines.

17. The system of claim 13, wherein the memory unit includes random access memory